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Prevalence of persistent apical periodontitis in patients with root canal-filled teeth: A cone-beam computed tomography study

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Abstract

Aim: Apical periodontitis is the inflammatory destruction of periradicular tissues that occurs gradually over time, primarily originating from invading bacteria in the root canal system and initiated by the release of bacterial products. In this study, the prevalence of post-treatment apical periodontitis was assessed with cone-beam computed tomography imaging and the effects of tooth-level and patient-level factors that may predict the failure of root canal treatment were investigated in a Turkish subpopulation.

Material and Methods: Our study included 305 cone-beam computed tomography images of patients (153 males, 152 females aged 18 to 78 years) [Mean ± standard deviation (SD) = 39.2 ± 17.6].

Results: Post-treatment apical periodontitis prevalence was 83.3% and was more common in the premolars (9.5%), the mandible (11.8%), and the left side of the jaw (11.8%).

Discussion: This study showed a high prevalence of post-treatment apical periodontitis in a Turkish subpopulation even in cases in which the quality of root canal filling appeared to be sufficient radiologically. Cone-beam computed tomography is one of the most sensitive imaging techniques for the detection of apical periodontitis.

Keywords

Apical Periodontitis, Cone-Beam Computed Tomography, Root-Canal Filling

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Introduction

Apical periodontitis (AP) is an inflammatory destruction of the periradicular tissues that occurs progressively over time, primarily originating from invading bacteria in the root canal system and initiated by the release of bacterial products [1]. It is well known that there is a healing response and tissue repair in the wounded periapical area if adequate root canal treatment (RCT) is performed [2], but this may not be the case in all cases. More recent studies show a remarkably high prevalence of AP in root canal-treated teeth [3-5]. Persistent AP lesions alone or when coupled with other predisposing factors may lead to tooth loss [6]. Besides, an increasing number of studies have shown that there has been mounting evidence of a bidirectional relationship between AP and systemic diseases [7]. This is consistent with the concept that endodontic infections affect systemic health, and systemic diseases similarly impact the pathogenesis of AP.

Post-treatment AP may be associated with many factors [8]. In previous studies, the effects of tooth-level factors (position, tooth type) [9, 10] and patient-level factors (gender, presence of systemic diseases) [11, 12] on the prevalence of post-treatment AP have been investigated. In this study, it was assumed that as patient-level risk factors, the presence of diabetes, cardiovascular diseases, and hematological disorders may interfere with the periapical healing in root-canal filled teeth.

Cone-beam computed tomography (CBCT) imaging has become a reliable diagnostic tool in pathologies of periradicular tissues and also provides three-dimensional views of the root canal system. In two-dimensional imaging, detailed assessment can not be carried out based upon a single view, due to structural superimpositions. Correspondingly, previous studies showed that CBCT has the highest sensitivity and diagnostic accuracy for detecting AP lesions [13, 14]. Therefore, in this study, CBCT images were utilized to evaluate the prevalence of AP in root canal-treated teeth.

Cross-sectional studies can be very helpful in ascertaining the true prevalence of specific diseases that are common in the population but whose effects are unknown or underestimated [3]. By assessing the current prevalence of AP in individuals with root canal-treated teeth, clinicians can be informed about possible contributing factors associated with post-treatment AP, also healthcare providers may be encouraged to set standards enhancing the procedural quality of RCT. In this study, the prevalence of post-treatment AP was investigated with CBCT examination and the effects of tooth-level and patient-level factors on RCT outcome were evaluated in a Turkish subpopulation. The null hypothesis of this study was that both tooth level and patient level factors did not contribute to differences in the success of the RCT.

Material and Methods

Sample selection

The study was conducted at the Oral and Maxillofacial Radiology Department, Nuh Naci Yazgan University and included 305 CBCT images of patients (153 males, 152 females) between 18 and 78 years [Mean ± standard deviation (SD) = 39.2 ± 17.6] that were taken between January 2020 and April 2022. This study was approved by the Ethics Boards and Commissions of Nuh Naci Yazgan University, Kayseri, Turkey (2022/18).

Inclusion and exclusion criteria

The study was conducted with CBCT images taken from patients over the age of 18 between 2020-2022. Teeth with apical periodontitis, which have radiologically adequate coronal restorations and also have radiologically adequate root canal fillings according to criteria established in a previous study were evaluated [15].

CBCT images of patients with poor image quality, artefacts, and patients younger than 18 years of age were not included. In addition, CBCT images of teeth with radiologically inadequate upper restoration and teeth with radiologically low-quality root-canal fillings were excluded from this study.

Image acquisition

The 3D digital imaging system (KaVO OP 3D Pro, PaloDEx Group Oy, Tuusula, Finland) with a fixed protocol and parameters was used for acquiring CBCT images. With the tomographic KaVO OP 3D Pro CBCT scanner the following parameters were utilized to obtain the images used in this study: (i) exposure setting of 90 kV, 8 mA, (ii) Exposure time- 17.5-26.9 s, (iii) 13×15 cm of field of view (FOV), and (iv) voxel size-0.320 mm. All CBCTs were taken for the purpose of a dental check-up. In this research, these CBCT images were not specifically taken for the examined endodontically treated teeth.

Image evaluation

OnDemand 3D Imaging Software (Cybermed, Seoul, South Korea) was used for the image reconstruction and measurements. First, the images were reconstructed in sagittal, axial, and coronal planes and furthermore, multiplanar reconstruction (MPR) was performed for a comprehensive view of the root canal system. The MPR was performed by navigating through the coronal-apical direction and then in the apical-coronal direction. During the 3D inspection if the images of one of the three planes (sagittal, axial, coronal) were unclear, the actions were repeated.

Statistical analysis

The collected data were analyzed using SPSS (Version 22.0, IBM Corporation, New York, USA) for Windows. The association between risk factors [gender, type of teeth (premolar/molar), jaws (maxillar/mandibular), location of teeth (right/left) the presence of systemic diseases (cardiovascular, hemophilia, and diabetes mellitus) and apical periodontitis were determined using Chi-square test. The statistical level of significance was set with a p-value of 0.05.

Ethical Approval

Ethics Committee approval for the study was obtained.

Results

Reliability-inter and intra-examiner

There inter-examiner agreement (Kappa ≥ 0.85) was excellent for the presence/absence of AP and was moderate for the presence/absence of endodontically treated teeth associated with AP (Kappa < 0.75). There was excellent intraexaminer reliability for both the first and second examiners with Kappa scores of ≥ 0.88; ≥ 0.97, respectively, with regard to assessing AP in non-treated and previously root canal-treated teeth.

When the data were analysed according to systemic diseases,

Table 1. Variation in prevalence of apical periodontitis between the jaws, according to gender, type of teeth, and location.

Apical Periodontitis	Gender		Total cases (%)	P
	Female (n=152)	Male (n=153)		
Number	129 (84.9)	125 (81.7)	254 (83.3)	
Type of Teeth				
Premolar	16 (10.5)	13 (8.5)	29 (9.5)	0.194
Molar	7 (4.6)	15 (9.8)	22 (7.2)	
Location				
Right side	7 (4.6)	8 (5.2)	15 (4.9)	0.752
Left side	16 (10.5)	20 (13.1)	36 (11.8)	
Type of Jaws				
Maxilla	6 (3.9)	9 (5.9)	15 (4.9)	0.680
Mandibula	17 (11.2)	19 (12.4)	36 (11.8)	

Table 3. Evaluation of the factors affecting AP with simple binary logistic regression analysis.

	β	se	Wald Statistics	p	Exp(β)	95% C.I.for exp(β)	
						Lower	Upper
Gender							
Female	Ref						
Male	0,228	0,308	0,549	0,459	1,256	0,687	2,298
Age	-0,015	0,011	1,925	0,165	0,985	0,965	1,006
KVS	-1,461	0,743	3,871	0,049	0,232	0,054	0,994
DM	-1,506	1,035	2,114	0,146	0,222	0,029	1,688

β: Regression coefficient, S.E: Standard error of β, Exp(β): Odds ratio, C.I.: Confidence interval

Table 2. Variation in the prevalence of apical periodontitis in the presence of specific systemic diseases.

Apical Periodontitis	CVS		Total of cases (%)	P	DM		Total of cases (%)	P
	No (n=265)	Yes (n=40)			No (n=283)	Yes (n=22)		
No	216 (81.5)	38 (95)	254 (83.3)		233 (82.3)	21 (95.5)	254 (83.3)	
Type of teeth								
Premolar	28 (10.6)	1 (2.5)	29 (9.5)	0.103	28 (9.9)	1 (4.5)	29 (9.5)	0.253
Molar	21 (7.9)	1 (2.5)	22 (7.2)		22 (7.8)	0 (0)	22 (7.2)	
Location								
Right side	15 (5.7)	0 (0)	15 (4.9)	0.89	15 (5.3)	0 (0)	15 (4.9)	0.266
Left side	34 (12.8)	2 (5)	36 (11.8)		35 (12.4)	1 (4.5)	36 (11.8)	
Type of Jaws								
Maxilla	15 (5.7)	0 (0)	15 (4.9)	0.89	15 (5.3)	0 (0)	15 (4.9)	0.266
Mandibula	34 (12.8)	2 (5)	36 (11.8)		35 (12.4)	1 (4.5)	36 (11.8)	

CVS: Cardiovascular Diseases, DM: Diabetes Mellitus

no apical periodontitis cases were found in hemophilia patients. In Table 3, the effects of gender, age, CVS, and DM variables on AP were investigated. Variables with a p-value of <0.25 in Table 1 were evaluated with multiple binary logistic regression analyses. In order to determine the final model (Final Model), variables that are not statistically significant were removed from the model with the Backward Wald elimination method. As a result, the CVS variable was found to be effective on the network. The presence of CVS reduces the risk of AP occurrence by 4,310 times. This result can be considered incidental.

Discussion

The focal infection theory was an exaggerated concept, which has been put forward in the early 1900s [16], claiming a causal relationship between oral infections and systemic diseases and building consensus in medicine in the 1920s without adequate testing [17]. Recently, as a result of the widespread application of root canal therapy and advances in diagnostic imaging, it has been revealed that the prevalence of apical periodontitis after RCT is higher than expected [3, 5, 12]. If undiagnosed, the local effects of AP are at worst limited to tooth loss [6], but in many studies, it has been reported that untreated AP may contribute to low-grade systemic inflammation in the body [18-20]. AP is an inflammatory disease that affects the supporting tissues of the apical part of the tooth root, usually asymptomatic, diagnosed by radiological examination [21]. In the present study, the prevalence of persistent AP was assessed in a Turkish subpopulation and its relationship with systemic diseases was evaluated using CBCT.

Post-treatment AP was observed in at least one tooth in 83.3% of the patients, which is a very high prevalence. Siqueira et al. [4] observed AP in 29% of teeth with adequate root canal treatment and coronal restoration in their study on periapical radiographs. Kirkevang et al. [22] in their study with conventional radiography in the Danish population, have found the prevalence of AP to be 31.2% in teeth with adequate root canal filling and coronal restoration. Al-Omari et al. [10] conducted a study with panoramic radiography and reported that in 72.4% of endodontically treated teeth, endodontic treatment was inadequate and apical periodontitis was observed in 87.0% of them. Kalender et al. [23] examined adequately treated root canal-filled teeth with periapical and panoramic radiographs and they detected AP in 26.6% of them. The reason for this significantly higher rate in our study may be related to the population difference and may be aroused from the fact that CBCT is much more sensitive in the diagnosis of AP. Abella et al. [13] found a significantly higher prevalence rate of AP lesions detected by CBCT and emphasized the key clinical features of CBCT in the diagnosis. Dutra et al. [14] investigated the sensitivity of imaging methods in diagnosing AP and stated that CBCT scans gave excellent accuracy.

According to Al-Omari et al. [10], AP is more frequent in

maxillary teeth compared to mandibular teeth. In this study, the prevalence of AP was found to be higher in the mandible (11.8%) than maxilla (4.9%). Alternative imaging techniques, treatment modalities, and conducting studies in different populations may explain the controversial results. Also in the same study, Al-Omari et al. [10] found no association between AP and gender. In our study, there was no statistical difference between the genders regarding the prevalence of post-treatment AP. In this regard, our findings are compatible with Al-Omari et al's work. Although there was no significant difference in our study, AP was more common in females (84.9%) compared to males (81.7%).

There are reports in the literature suggesting that there is a potential relationship between systemic diseases (cardiovascular diseases, diabetes, blood disorders, etc.) and the pathogenesis of AP [7, 24, 25]. While acknowledging that systemic diseases have an increasing effect on the possibility of post-treatment AP, in their systemic review, Aminoshariae et al. concluded that the available scientific evidence is insufficient to determine whether diabetes and cardiovascular diseases are associated with endodontic outcomes [7]. However, more recently Gupta et al. [11]. revealed a strong association between diabetes and AP in a meta-analysis study. This study evaluated the relationship between post-treatment AP and some specific systemic diseases (cardiovascular diseases, blood diseases, and diabetes mellitus). No cases of previously root-filled teeth with apical periodontitis were encountered in patients with hemophilia. According to the results of the present study, it could not be established any significant relationship between post-treatment AP and cardiovascular disease diabetes. The limitation of this research is the low number of patients with systemic disease in the study group.

Conclusion

This study showed a high prevalence of persistent AP in the Turkish population, although root canal filling was sufficient radiologically. CBCT is an important imaging method in the diagnosis of apical periodontitis, with a higher radiation dose compared to other imaging methods. Periapical conditions of root canal-filled teeth should be radiographically examined in larger populations. In addition, long-term radiographic follow-up of teeth with an adequate root canal and crown filling is recommended.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

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